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A Study of Separating Fish from *Nephrops norvegicus* L. in a Bottom Trawl

J Main and
G I Sangster

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A Study of Separating Fish from *Nephrops norvegicus* L. in a Bottom Trawl

J Main and G I Sangster

Marine Laboratory Aberdeen

Introduction

Knowledge, based on direct observation, on the behaviour of fish in relation to the components of fishing gear is increasing, but it is sometimes difficult to be aware of the implications of such information and to use it to its best advantage. Recent work has shown that fish react in different ways when entering a bottom trawl in daylight (Main and Sangster, 1981a). Flatfish (plaice *Pleuronectes platessa* L., common dab *Limanda limanda* (L.) and lemon sole *Microstomus kitt* (Walbaum)), skates (Rajidae) and cod (*Gadus morhua* L.) enter the net very close to the sea bed whereas haddock (*Melanogrammus aeglefinus* (L.)) rise up from the sea bed when tiring and drop back high into the net. Preliminary studies based on this information have shown that horizontal separator panels of netting, rigged at the correct height inside the net with independent cod-ends, will separate various species of fish when they enter the net (Main and Sangster, 1981a). In the *Nephrops* fishery the by-catch of fish can be predominantly of undersized commercial species (Symonds and Simpson, 1971; Warren, 1974; Warren and Lovewell, 1976). If, when trawling for the Norway lobster, *Nephrops norvegicus* (L.), this catch could be separated and only those fish of marketable size selected *in situ*, it would lead to better management of the fish stocks.

This type of selective fishing was considered for the specific purpose of separating haddock and whiting (*Merlangius merlangus* (L.)) from a mainly *Nephrops* catch. This paper describes the experiments carried out using a modified commercial fishing gear and discusses the results.

Materials and Methods

Experiments were conducted during 1981 in daylight on commercial *Nephrops* fishing grounds (depth 90 – 125 m) around the Small Isles near Mallaig, Scotland, using the local commercial stern trawler 'Orcades' OB 232 (320 hp, 22 m). This vessel also towed the diver-operated underwater vehicle TUV II (Plate I) during the shallow water (30 – 36 m) gear-measuring and direct observation periods. Towing speed was monitored using speed logs (flowmeter type, giving $\pm$ 1% accuracy over maximum range of 5.15 m s^{-1} or 10 knots) on board the towing vessel and on the TUV II. The duration of the trawl tows varied from one to four hours. The net used was a Boris 520 dual purpose fish/prawn trawl re-rigged with a second fishing line and cod-end, using a separator panel which divided the net into two horizontal compartments (Plate II). Two separator panels were tested and made up from netting 50 mm and 85 mm mesh size respectively. The level of the additional fishing line could be varied by using the correct lengths of rope strop tied at the quarters as shown in Figure 1. The trawl boards were steel, rectangular Vee-type (2.0 x 1.2 m). The net and its rigging specifications are described in Figure 2. Trawl board spread, wing

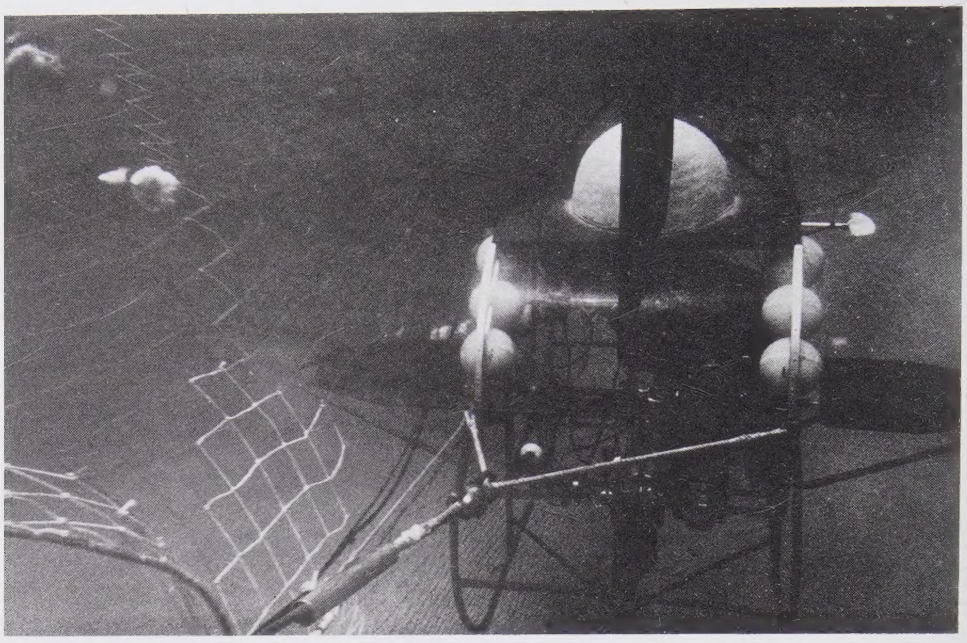

Plate I. The Towed Underwater Vehicle (TUV II) on the port side of the trawl. The pilot has positioned the vehicle hard against the wing allowing the cameraman to film inside the mouth of the trawl with relative ease.

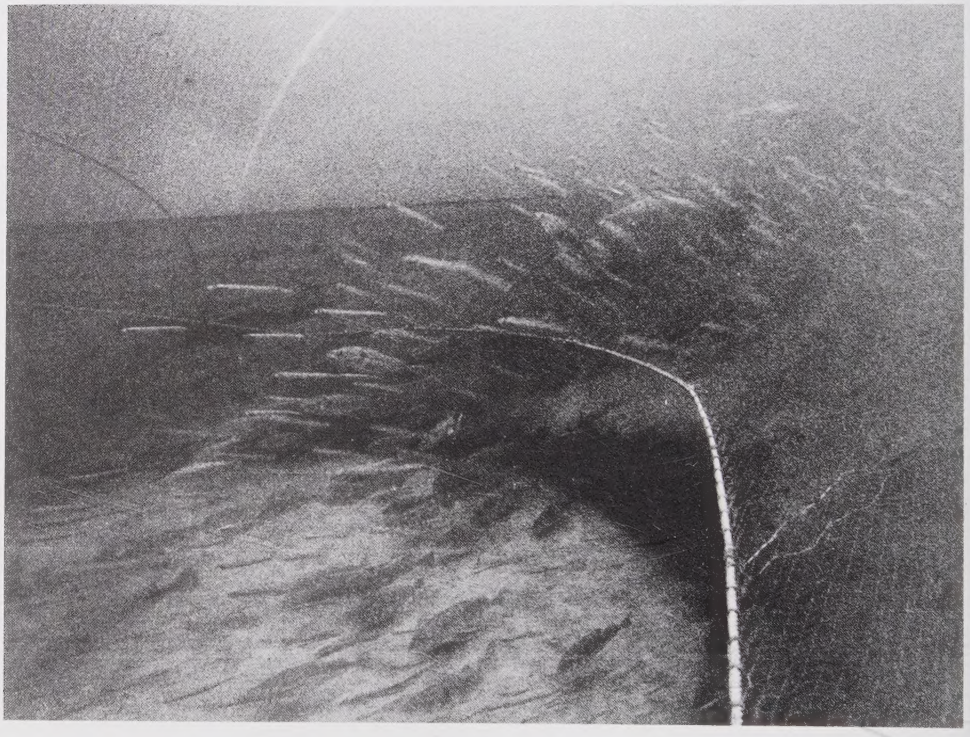

Plate II. The Boris 520 Fish/Prawn trawl with the 50 mm mesh separator panel. Haddock and sandeels (Ammodytidae) rising off the sea bed as they tire and drop back into the net. Photograph taken on sandy bottom at towing speed of 1.54 m s^{-1} (3 knots).

Figure 1. Sketch of the Boris 520 Fish/Prawn trawl showing the positions of the rope strops which control the level of the separator panel.

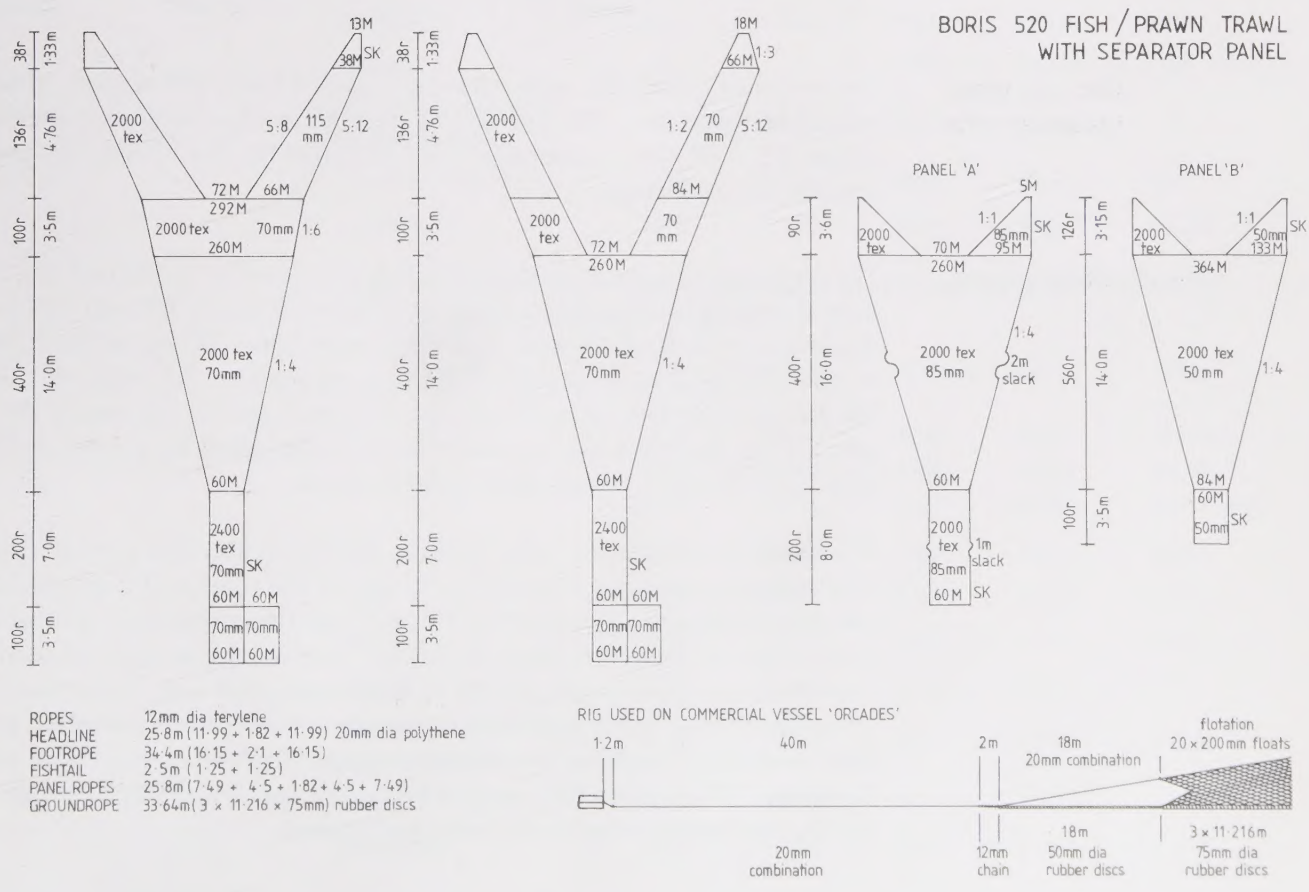
BORIS 520 FISH / PRAWN TRAWL
WITH SEPARATOR PANEL
PANEL 'A'
PANEL 'B'
ROPES 12mm dia terylene
HEADLINE 25·8m (11·99 + 1·82 + 11·99) 20mm dia polythene
FOOTROPE 34·4m (16·15 + 2·1 + 16·15)
FISHTAIL 2·5m (1·25 + 1·25)
PANEL ROPES 25·8m (7·49 + 4·5 + 1·82 + 4·5 + 7·49)
GROUNDROPE 33·64m (3 × 11·216 × 75mm) rubber discs
RIG USED ON COMMERCIAL VESSEL 'ORCADES'
flotation
20 × 200mm floats
20mm combination
12mm chain
18m 50mm dia rubber discs
3 × 11·216m 75mm dia rubber discs

Figure 2. Net diagrams and rigging specification of the Boris 520 Fish/Prawn trawl with both sizes of separator panel.

end spread and headline and upper fishing line heights were measured using a diver-operated hand held sonar unit. This method of obtaining gear dimensions *in situ* is described by Main and Sangster (1981b). The technique of direct observation by divers using a low light television camera from the TUV II is described by Main and Sangster (1978a, 1978b, 1979). The contents of the two cod-ends were measured or counted on completion of each haul. Cod-end mesh sizes were measured using the ICES measuring gauge.

Results

Measurements of Fishing Gear

The linear dimensions of the gear while being towed in shallow water (36 m) are given in Table I. These measurements were found to be the same for both the 50 mm and 85 mm separator versions of the trawl, using 137 m (75 fathoms) of trawl warp between the ship and the otterboards.

Table I. Fishing gear dimensions and towing speed with separator panel at four different heights

	106 cm strop length	60 cm strop length	45 cm strop length	75 cm strop length
Trawl board spread	26 m	26 m	26 m	Not measured
Wing end spread	10.3 m	10.3 m	10.3 m	10.3 m
Headline height	3.55 m	3.35 m	3.05 m	3.35 m
Separator panel height	106 cm	60 cm	45 cm	75 cm
Wing end height	1.8 m	1.8 m	1.8 m	1.8 m
Towing speed	1.4 to 1.5 $m\ s^{-1}$ (2.7 to 2.9 knots)	1.4 to 1.5 $m\ s^{-1}$ (2.7 to 2.9 knots)	1.4 to 1.5 $m\ s^{-1}$ (2.7 to 2.9 knots)	1.4 to 1.5 $m\ s^{-1}$ (2.7 to 2.9 knots)

Cod-end mesh measurements

Cod-end mean stretched mesh size readings of 67 mm (40 random meshes measured, range 64 – 69 mm) and 72 mm (40 random meshes measured, ranged 65 – 76 mm) respectively were obtained for the 70 mm top and bottom cod-ends used.

Diver's Observations

The *Nephrops* fishery around Mallaig is predominantly a daylight one and we were therefore able to observe and record the behaviour of both fish and *Nephrops* in front of the gear in shallow water (30 – 36 m) without the use of artificial lighting. In daylight *Nephrops* consistently fell back very low over the ground line when entering the net, almost always in the area of the bosom groundline. *Nephrops* did not swim up when disturbed by the groundline (Main and Sangster, unpublished observations).

Observations of haddock, cod, whiting, flatfish, skates and spotted dogfish (*Scyliorhinus caniculus* (L.)) in the mouth of the trawl and their reaction to the separating panel showed that the vast majority of haddock and whiting were caught in the upper level, while cod, flatfish, skates, spotted dogfish and *Nephrops* were caught mostly in the bottom cod-end. These reactions to a two-level trawl, some species rising up while others keep low when dropping back over the groundline, are similar to those obtained earlier (Main and Sangster, 1981a) when the reaction of various species of fish to a high opening 4-panel bobbin trawl in daylight was studied.

Separator Panel Height Above Sea Bed

In a first series of experiments, the fishing line of the 85 mm mesh separator panel was set at 106 cm, 60 cm and 45 cm directly above the groundline,

and Tables II, III and IV show the results of the catches with these three settings.

Table II. Catches from five daylight hauls in 85 mm mesh panel set 106 cm above bottom. Depth 90 – 109 m

Species	Top Level		Bottom Level		Total Catch of each species (numbers)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
Haddock	36.25	16-39	63.75	19-48	818
Cod	4.5	23-62	95.5	51-66	18
Whiting	65.0	14-34	35.0	18-32	585
Skates	0	-	100	21-47	9
Flatfish (plaice, and common dab)	1.4	24-45	98.6	28-45	49
Spotted Dogfish	0	-	100	52-75	126
Nephrops	11.1	19-47*	89.9	19-44*	61,353

Table III. Catches from six daylight hauls in 85 mm mesh panel set 60 cm above bottom. Depth 100 – 125 m

Species	Top Level		Bottom Level		Total Catch of each species (numbers)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
Haddock	80.8	18-63	19.1	19-41	721
Cod	16.5	54-62	83.5	34-71	9
Whiting	80.1	17-41	19.9	21-31	140
Skates	0	-	100	34-56	54
Flatfish (plaice and common dab)	0.9	24-31	99.1	22-37	670
Spotted Dogfish	1.5	55-76	98.5	52-81	197
Nephrops	13.5	21-51*	86.5	19-47*	5,853

Table IV. Catches from five daylight hauls in 85 mm mesh panel set 45 cm above bottom. Depth 90 – 120 m

Species	Top Level		Bottom Level		Total Catch of each species (numbers)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
Haddock	86.2	23-59	13.8	20-41	867
Cod	45.5	18-64	54.5	17-61	112
Whiting	74.8	21-35	25.2	17-41	194
Skates	3.2	45-49	96.8	34-53	113
Flatfish (plaice and common dab)	11.5	17-34	88.5	17-37	1,397
Spotted Dogfish	8.9	58-70	91.1	56-78	1,142
Nephrops	16.7	17-49*	83.3	17-51*	4,340

* Carapace length in mm

Many spotted dogfish became meshed in the 85 mm separator panel just in front of the lower cod-end. This caused delays owing to the crew having to clear the fish from this inner panel prior to re-shooting the gear. Furthermore, with a separator panel of this mesh size, a large proportion of *Nephrops* passed from the lower into the upper part of the net, either during trawling or by being shaken through the 85 mm mesh during hauling. It was also concluded that the 60 cm setting of the second fishing line above the sea bed was approximately correct. The 85 mm panel was removed and a series of hauls was carried out using a small mesh (50 mm) separator panel set at 60 cm and 75 cm. The results of these eight trawl hauls are shown in Tables V and VI respectively.

Table V. Catches from five daylight hauls in 50 mm separator panel set 60 cm above bottom. Depth 90 – 125 m

Species	Top Level		Bottom Level		Total Catch of each species (numbers)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
Haddock	91.4	23-43	8.6	18-41	607
Cod	9.0	27-37	91.0	27-43	32
Whiting	77.9	21-37	22.1	17-27	559
Skates	0.8	-	99.2	44-56	96
Flatfish (plaice and common dab)	0.6	17-34	99.4	14-35	1,750
Spotted Dogfish	4.2	58-70	95.8	61-78	1,337
Nephrops	1.4	29-39*	96.8	19-42*	3,992

Table VI. Catches from three daylight hauls in 50 mm separator panel set 75 cm above bottom. Depth 90 – 125 m

Species	Top Level		Bottom Level		Total Catch of each species (numbers)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
Haddock	96.0	21-41	4.0	19-28	782
Cod	0	-	100	34-36	11
Whiting	94.1	21-25	5.9	21-25	33
Skates	0	-	100	Not measured	13
Flatfish (plaice and common dab)	0.8	23-32	99.2	17-34	331
Spotted Dogfish	0	-	100	61-78	120
Nephrops	0.7	27-34*	99.3	19-48*	2,830

* Carapace length in mm

Discussion

Direct Observation

The results of trawling in deeper water (90 – 125 m) (Tables V and VI) confirm our direct observations, showing few *Nephrops* in the top cod-end.

French scientists have carried out similar fishing trials on a mixed *Nephrops*/hake (*Merluccius merluccius* (L.)) fishery in the Bay of Biscay using a 4-panel trawl with separate lower and upper cod-ends. The success in separating small fish from the shellfish depended on the design of the horizontal splitting panel (Prado, 1979 and personal communication). The main

advantage, however, of using the TUV II diving technique is that the whole gear can be seen, measured and adjusted to suit the fish and *Nephrops* behaviour during normal towing conditions.

Species Separation

Using the larger mesh (85 mm) set at its highest level (106 cm), a large proportion of the haddock and whiting was caught in the bottom cod-end, mixed with the *Nephrops* and other species (Table II). With the lowering of the separator panel height to 60 cm above the sea bed (Table III), a greater percentage of haddock and whiting was guided into the top cod-end. *Nephrops*, however, were also found in this cod-end. With the panel set at only 45 cm above the ground level (Table IV), unacceptably large proportions of *Nephrops*, cod, flatfish, skates and spotted dogfish were caught in the top cod-end. The sieving of *Nephrops* through the separator panel, either during the tow or while the gear was being hauled was considered a possible reason for the appearance of *Nephrops* in the top cod-end. When the 85 mm panel was replaced with the small mesh (50 mm) separator panel set at a 60 cm height, it was found that *Nephrops* were caught mainly in the bottom cod-end and haddock and whiting in the top one (Table V). A small quantity of cod, flatfish, spotted dogfish and skates, however, were still caught in the top cod-end (Table V). By raising the 50 mm small mesh separator panel to 75 cm above the bottom (Table VI), the most favourable separation of haddock and whiting from *Nephrops* and groundfish (cod, flatfish, skates and spotted dogfish) was achieved.

Comparison of Fish Quality in the two Cod-ends

It was immediately noticeable that the firm condition and appearance of the haddock and whiting in the top cod-end were far better than in the bottom one. In the lower cod-end, scaling damage, bruising and chafing were caused by stones, weed, crustaceans and various benthic organisms. These items were absent from the top cod-end. On one occasion 14 baskets of trash (weed, stones, etc) was sorted from the fish caught in the bottom cod-end.

How Best to Use the Two Level Trawl

These experiments show that it is possible to control the fate of the roundfish species when trawling without losing *Nephrops.* By using gear of the principles here described, it could be arranged:

(a) to catch both *Nephrops* and prime condition haddock and whiting in a less damaged condition while minimising the time wasted on deck sorting out the catch;

(b) to release the haddock and whiting from the top cod-end when trawling, by leaving the cod-end open, when permissible quotas for these species had been achieved, or the prices for haddock and whiting were such that it would be uneconomical to land them; or

(c) to increase the top cod-end mesh size, so that only the larger fish were retained. The flexibility of this method of fishing could lead to less dumping of unwanted marketable size fish at sea.

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Summary

The 50 mm separator panel set at 75 cm above the footrope of the modified Boris 520 fish/prawn trawl was found to be the most favourable arrangement for the separation of haddock and whiting from *Nephrops* and groundfish (cod, flatfish and skates).

Direct observation showed that *Nephrops* did not swim up when disturbed by the groundline. The vast majority passed back into the net only in the area of the bosom groundline.

The quality and condition of haddock and whiting in the top cod-end was far superior to the fish caught in the lower one. Fish in the bottom cod-end suffered damage owing to abrasions caused by *Nephrops* and large quantities of trash (weed, stones, etc).

The flexibility of this type of gear may lead to a better management of fish stocks and should help to prevent dumping of fish at sea.

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